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The Prevalence and Risk Factors of Abnormal Vision Among Preschool Children

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Background: The presence of abnormal vision during early childhood has been shown to have a substantial impact on the development of visual, motor, and cognitive functions, potentially resulting in long-term adverse psychosocial outcomes. The objective of this study was to examine the prevalence and associated risk factors of abnormal vision among preschool children aged 4–6 years in Shaoxing, China.

Methods: A cross-sectional study was conducted from March to May 2023 in Shaoxing, involving a sample of 9913 children within the specified age range. Parents were interviewed using a structured questionnaire that gathered information on sociodemographic characteristics and other relevant factors.

Results: The study revealed that 14.4% of participants had abnormal vision. Logistic regression analysis indicated that individuals who watched TV for more than 3 hours daily had a 2.206 times higher likelihood of developing abnormal vision ($P<0.05$). Additional risk factors for abnormal vision included watching TV at a distance of less than 3 meters, misalignment of eyes and screen while watching TV, early exposure to electronic devices before the age of 2, parents are unaware of the impact of chewing on eye development, and lack of promotion of good eye habits in children ($P < 0.05$). An association was found between parent's and children's refractive error ($P < 0.05$), with good family lighting and a balanced dietary structure being identified as protective factors against abnormal vision.

Conclusion: The study concluded that exposure to electronic products was a significant factor in the development of abnormal vision among children aged 4–6. Furthermore, family environment and genetic predisposition were also found to influence vision. Regular ocular screenings and early interventions may be effective in preventing abnormal vision.

Keywords: risk factors, abnormal vision, preschool children, China

Introduction

Vision gradually develops and matures with the development of the refractive system and retina. The period from 0 to 6 years old is critical for children's vision development. Children's visual system can form stable images at about 3 years old, and the plasticity of their visual nervous system is high at about 5 years old but decreases with age. Studies have shown that the highest incidence of vision problems in children occurs between the ages of 4 and 6. The unaided vision of a four-year-old child can usually reach 0.6 or higher, and by the age of 5 and older, it can generally reach 0.8 or higher. If children's vision does not meet these standards or if there is a binocular vision difference of 0.2 or more, it is called abnormal vision, mainly due to myopia, hyperopia, astigmatism, anisometropia, strabismus or developmental delay.

Abnormal vision has become a global health issue. Refractive error is the most significant cause of abnormal vision among children, accounting for 47–92% of all ocular morbidities (no matter how much vision is lost as a result).[1] Abnormal vision or blindness affects at least 2.2 billion people worldwide, including an estimated 19 million children aged 0 to 14, among whom 1.4 million have irreversible blindness.[2] Childhood is a crucial period for visual development.[3] Visual loss during the preschool stage can cause permanent visual impairment that cannot be corrected. The physiology and anatomy of the visual system are malleable during this stage.[4,5] Therefore, vision screening for preschool children is an integral part of preventive pediatric healthcare, according to many healthcare specialists and

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governments. Identification and intervention of children with vision problems improves their quality of life.[6,7] The National Health Commission (NHC) of the People's Republic of China (PRC) has recently published service specifications for pediatric eye care and vision examinations. This development holds significant practical importance for vision screening in preschool children.

Although most people with abnormal vision have normal visual acuity when appropriately corrected, abnormal vision is a risk factor for myopic maculopathy, retinal detachment, subretinal neovascularization, cataracts and glaucoma in adult life. The risk increases with the severity of abnormal vision.[8] Since myopia progression is rapid during school-age years, it is very important to prevent or slow the progression and reduce the risk of pathological abnormal vision. Therefore, finding methods to reduce progression of abnormal vision is becoming increasingly important. To evaluate the eye health status of preschool children and prevent the occurrence of abnormal vision, it is of great significance to understand the prevalence and influencing factors of abnormal vision in preschool children in China. Preschool-aged children could benefit from early interventions to correct or improve their vision by screening them for abnormal vision. China has few large-scale vision screening studies for preschoolers. This article aims to understand the current status of abnormal vision among preschool children in eastern China based on the Shaoxing City Children's Vision Screening Work and analyze its influencing factors among children aged 4 to 6 years, in order to provide a reference for the development of prevention and control measures for childhood abnormal vision.

Materials and Methods

Study Subject

According to the cross-sectional study, the sample size was determined. The calculation formula was $n = \frac{\mu^2_{\alpha/2} P(1-P)}{\delta^2}$ ($\alpha = 0.05$, $\delta = 0.03$, and p is the prevalence of childhood abnormal vision). A study showed that the prevalence of hypertension in children aged 6–13 years in China was 13.1%.[9] According to the formula of sample size, the sample size should be 486 ($641 = 1.96 \times 1.96 \times 0.184 \times (1-0.131)/0.03/0.03$); however, the 5% of sample size needed to be increased for sampling error. Therefore, the minimum sample size was 511 ($511 = 486 \times (1 + 0.05)$). In fact, the effective sample size was 9913. The random sampling method was used to select participants in this study, 9913 preschool children aged 4–6 years were enrolled, including 5155 boys (52.0%) and 4758 girls (48.0%).

Study Design

This was a retrospective observational study that collected data from large-scale preschool vision screening results in the city from March to May 2023. The participants who met the following criteria were included in the study: (a) Children aged 4 to 6; (b) Children and their parents who voluntarily participate in this survey. Exclusion criteria: (a) History of ocular trauma, history of eye surgery, and other severe eye conditions such as congenital cataracts, congenital glaucoma, etc.; (b) Severe systemic or mental illness; (c) Exclude other eye diseases and those who cannot understand or cooperate during the examination process.

The determination of visual acuity was based on the "Service Specification for Children's Eye Health and Vision Screening" issued by the National Health Commission of the People's Republic of China. Children aged 4 with uncorrected visual acuity ≤0.6, children aged 5 and above with uncorrected visual acuity ≤0.8, or those with a difference of two lines or more in visual acuity between the two eyes (using the standard logarithmic visual acuity chart), or a difference of 0.2 or more in visual acuity between the two eyes (using the international standard visual acuity chart), are considered to have low normal vision. After conducting vision exams in kindergartens, pediatricians entered the visual acuity data into the Shaoxing Maternal and Child Health Management Platform. Parents voluntarily signed informed consent forms and completed a questionnaire on factors influencing abnormal vision online.

Data Collection

The visual acuity data came from the Shaoxing Maternal and Child Health Management Platform. Other data collection came from a self-designed "Children's Eye Health Questionnaire" that included basic information such as gender, date of birth, birth week, birth weight, parents vision status and age, the time and distance when watch TV, the positional

relationship between eyes and screen (TPRBEAS), first contact with electronic products age (FCWEPA), home lighting, whether particular about food choices, dietary structure, sleeping time at night, total sleep time per day, parents' awareness of the impact of a high-sugar diet on myopia (PAOTIOAHSDOM) and the effect chewing on eye muscle development, parents whether cultivate children's good eye habits and take their children for regular visual examinations.

Statistical Analyses

Data were analyzed using SPSS 25.0 software. The data were described using proportions or mean ± standard deviation. The chi-square test was used to evaluate the association between two categorical variables. Logistic regression models were used for the analysis of the association between abnormal vision and risk. P <0.05 was considered statistically significant.

Ethical Considerations

The study protocol has been approved by the Medical Ethics Committee of Shaoxing Maternity and Child Health Care Hospital. Participant personal information and identifying details will be excluded from the study to ensure anonymity and privacy.

Results

Baseline Characteristics of the Participants

The collected data from 10621 children of whom 9913 had valid data and were included in our analysis, the ratio of children in streets to those in townships is approximately 2:1, including 5155 boys (52.0%) and 4758 girls (48.0%), preterm infants account for 12.4%, post-term infants account for 12.96%, low birth weight infants account for 10.09%, and fetal macrosomia account for 10.19%. The age of included participants ranged from 4 to 6 years, and with increasing age, the proportion of individuals with vision abnormalities is increasing. Abnormal vision was considered when a child has myopia, hyperopia, astigmatism, anisometropia, strabismus or other vision problems. In our study sample, 1431 (14.4%) had abnormal vision. From the perspective of birth week, birth weight, parental age, and abnormalities in vision, there is no significant difference. The proportion of mothers with abnormal vision is higher than that of fathers (41.88% vs 36.35%). A complete summary of sociodemographic characteristics in our study cohort stratified by streets and townships, age and gender distribution of children vision, as shown in Table 1 and Figure 1.

Factors Associated with Abnormal Vision in Single-Factor Analysis

The results indicated that the time of watch TV was significantly associated with abnormal vision ($\chi^2 = 31.047$, $P < 0.05$). The results indicated that the watch TV distance was significantly associated with abnormal vision ($\chi^2 = 26.524$, $P < 0.05$). The findings of this study indicate that TPRBEAS was significantly associated with abnormal vision ($\chi^2 = 14.922$, $P < 0.05$). FCWEPA was significantly associated with abnormal vision ($\chi^2 = 28.116$, $P < 0.05$). Dim light and particular about food choices were significantly associated with abnormal vision ($\chi2 = 15.144$, $P<0.05$) and ($\chi^2 = 20.96$, $P < 0.05$), respectively. Sleeping time at night and total Sleep time were significantly associated with abnormal vision ($\chi^2 = 22.56$, $P < 0.05$) and ($\chi^2 = 8.669$, $P<0.05$), respectively. Dietary structure, PAOTIOAHSDOM and parents' awareness of the effect chewing on eye muscle development (PAOTECOEMD) were significantly associated with abnormal vision ($\chi^2 = 27.129$, $P < 0.05$), ($\chi^2 = 10.379$, $P < 0.05$) and ($\chi^2 = 10.379$, $P < 0.05$), respectively. Parents' cultivate good eye habits in children (PCGEHIC) and parents' taking children to undergo regular visual examinations (PTCTURVE) were also associated with abnormal vision ($\chi^2 = 19.771$, $P < 0.05$) and ($\chi^2 = 73.571$, $P<0.05$), respectively. Father and mother who had abnormal vision were associated with their offspring to be abnormal vision ($\chi^2 = 31.782$, $P < 0.05$) and ($\chi^2 = 49.64$, $P < 0.05$), respectively. As documented in Table 2.

Multiple Logistic Regression Estimates of the Effect on Abnormal Vision

After adjusting for age and gender in the model, the analysis showed that watching TV for more than 3 hours every day was 2.206 (1.263–3.851) times more likely to result in abnormal vision compared to not watching TV. Watching TV at

Table 1 Sociodemographic Characteristics Analyze

	Street n (%)	Township n (%)	Total N (%)
Gender			
Male	3341(51.42)	1814(53.10)	5155(52.00)
Female	3156(48.58)	1602(46.90)	4758(48.00)
Age(years)			
4	2251(34.65)	1011(29.60)	3262(32.91)
5	2236(34.42)	1144(33.49)	3380(34.10)
6	2010(30.94)	1261(36.91)	3271(33.00)
Gestational (week)			
<34	118(1.82)	63(1.84)	181(1.83)
34–36	638(9.82)	410(12.00)	1048(10.57)
37–41	4890(75.27)	2509(73.45)	7399(74.64)
≥42	851(13.10)	434(12.70)	1285(12.96)
Birth Weight (g)			
<2000g	138(2.12)	68(1.99)	206(2.08)
2000–2499g	491(7.56)	303(8.87)	794(8.01)
2500–3999g	5197(79.99)	2706(79.22)	7903(79.72)
≥4000g	671(10.33)	339(9.92)	1010(10.19)
Father's Age	35.41±5.33	35.85±5.67	35.56±5.45
Mother's Age	33.68±4.84	33.72±5.26	33.69±4.99
Abnormal vision			
No	5569(85.72)	2913(85.28)	8482(85.56)
Yes	928(14.28)	503(14.72)	1431(14.44)
Father has abnormal vision			
No	3975(61.18)	2335(68.35)	6310(63.65)
Yes	2522(38.82)	1081(31.65)	3603(36.35)
Mother has abnormal vision			
No	3634(55.93)	2127(62.27)	5761(58.12)
Yes	2863(44.07)	1289(37.73)	4152(41.88)

a distance of less than 3 meters had a higher risk of abnormal vision compared to watching TV at a distance of more than 3 meters ($P < 0.05$). Eyes and screen not aligned horizontally while watching TV were 1.289 (1.124–1.479) times more likely to result in abnormal vision than when aligned horizontally. First exposure to electronic products at less than 2 years old and at 1 year old had a 1.37 (1.178–1.593) and 1.433 (1.141–1.801) times higher risk of abnormal vision, respectively, compared to first exposure at more than 3 years old. Dim lighting posed a higher risk of abnormal vision compared to good lighting ($P < 0.05$). According to dietary structure, preferring meat over a balanced diet was associated with a 1.149 (1.001–1.32) times higher risk of abnormal vision, while preferring vegetables over a balanced diet was

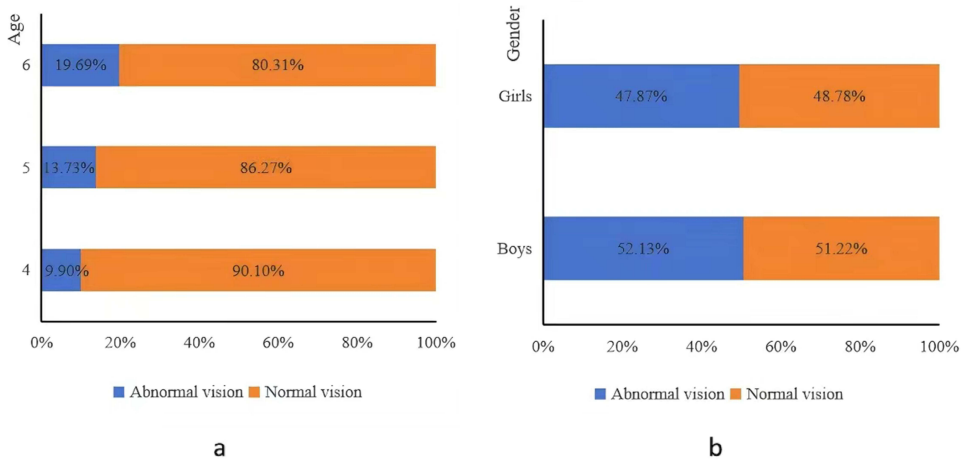

Figure 1 Age and gender distribution of vision.
Note: (**a**), Prevalence of abnormal vision in children of different ages. (**b**), Prevalence of abnormal vision in children of different genders.

associated with a 1.239 (1.029–1.493) times higher risk. Additionally, lack of awareness among parents about the effects of chewing on eye muscle development, not cultivating good eye habits in children, and parents having abnormal vision were also identified as risk factors for childhood abnormal vision ($P < 0.05$), as documented in Figure 2.

Table 2 Distribution of Risk Factors Associated with Abnormal Vision of Children

Variables	Normal vision n(%)	Abnormal vision n(%)	χ2	*P*
The time of watch TV			31.047	<0.05
Not watch	1200(85.5)	204(14.5)		
<30min	2430(85.9)	399(14.1)		
30min-60min	3234(86.6)	502(13.4)		
1hour-2hour	1230(84.6)	224(15.4)		
2hour-3hour	287(82.5)	61(17.5)		
≥3 hour	101(71.1)	41(28.9)		
Watch TV distance			26.524	<0.05
Not watch	1200(85.5)	204(14.5)		
<2 meters	1751(82.9)	361(17.1)		
2–3meters	4099(85.6)	687(14.4)		
≥3meters	1432(88.9)	179(11.1)		
TPRBEAS			14.922	<0.05
Not watch	1200(85.5)	204(14.5)		
On the horizontal line	5593(86.4)	880(13.6)		
Not on the horizontal line	1689(83.0)	347(17.0)		

(*Continued*)

Table 2 (Continued).

Variables	Normal vision n(%)	Abnormal vision n(%)	χ2	*P*
FCWEPA (year)			28.116	<0.05
Not contact	311(89.6)	36(10.4)		
<1	593(82.7)	124(17.3)		
1–2	2746(83.7)	536(16.3)		
2–3	2793(87.4)	402(12.6)		
≥3	2039(86.0)	333(14.0)		
Home lighting			15.144	<0.05
Good	8351(85.7)	1388(14.3)		
Dim	131(75.3)	43(24.7)		
Particular about food choices			20.96	<0.05
No	3847(87.4)	556(12.6)		
Yes	4635(84.1)	875(15.9)		
Dietary structure			27.129	<0.05
Balance	5279(87.0)	788(13.0)		
Prefer meat	2273(83.6)	447(16.4)		
Prefer vegetable	930(82.6)	196(17.4)		
Sleep time at night			22.56	<0.05
Before 20:00	104(92.0)	9(8.0)		
20:00–21:00	1886(87.6)	267(12.4)		
21:00–22:00	5013(85.5)	847(14.5)		
22:00–23:00	1404(82.7)	294(17.3)		
After 23:00	75(84.3)	14(15.7)		
Total Sleep time (hours)			8.669	<0.05
<7	173(86.9)	26(13.1)		
7–9	4273(84.6)	780(15.4)		
9–11	3841(86.5)	598(13.5)		
>11	195(87.8)	27(12.2)		
PAOTIOAHSDOM			10.379	<0.05
Yes	6199(86.3)	987(13.7)		
No	2283(83.7)	444(16.3)		
PAOTECOEMD			49.764	<0.05
Yes	5212(87.6)	738(12.4)		
No	3270(82.5)	693(17.5)		

(*Continued*)

Table 2 (Continued).

Variables	Normal vision n(%)	Abnormal vision n(%)	χ2	P
PCGEHIC				
Yes	8190(85.9)	1347(14.1)	19.771	<0.05
No	292(77.7)	84(22.3)		
PTCTURVE			73.571	<0.05
Yes	3993(82.5)	849(17.5)		
No	4489(88.5)	582(11.5)		
Father has abnormal vision			31.782	<0.05
No	5494(87.1)	816(12.9)		
Yes	2988(82.9)	615(17.1)		
Mother has abnormal vision			49.64	<0.05
No	5051(87.7)	710(12.3)		
Yes	3431(82.6)	721(17.4)		

Abbreviations: TPRBEAS, the positional relationship between eyes and screen; FCWEPA, first contact with electronic products age; PAOTIOAHSDOM, parents' awareness of the impact of a high-sugar diet on myopia; PAOTECOEMD, parents' awareness of the effect chewing on eye muscle development; PCGEHIC, parents' cultivate good eye habits in children; PTCTURVE, parents' taking children to undergo regular visual examinations.

Discussion

The outcomes of the present study indicate that 1431 (14.4%) of all 9913 children have abnormal vision in at least one eye. The results of this study are similar to those of preschool children in southern China, which was 13.1%.[9] In recent years, many studies have found that myopia prevalence has shot up dramatically among young people and children, reaching levels of 60–80% in East Asian countries and 25–40% in Western countries.[10,11] Vision loss affects at least 23 out of every 1000 preschool children in an under served South African community.[12] A meta-analysis of the prevalence of abnormal vision in Ethiopian children suggests that a total of 7647 children from nine studies were included. The overall prevalence of abnormal vision among children in Ethiopia was 7%.[13] A systematic review and meta-analysis of abnormal vision in children in the Eastern Mediterranean suggested that the prevalence of abnormal vision in children aged 5–17 years in the Eastern Mediterranean (EMR) was 11.57%.[14] The results of a large sample study in India suggest that older children, children from urban schools and private schools have an increased risk of visual impairment and myopia.[15] East Asian countries the myopia boom is attributed primarily to the educational pressure, which prompts children to read for long hours. This practice severely limits the time spent outdoors and reduces exposure to sunlight and far vision. As a consequence, the eyes grow longer and become myopic.[16]

In a single-factor analysis of this study, we noticed that the time of watch TV, watch TV distance, TPRBEAS, FCWEPA, home lighting, whether particular about food choices, dietary structure, sleep time at night, total sleep time, PAOTIOAHSDOM and the effect chewing on eye muscle development, parents cultivating good eye habits in children, parents taking children for regular visual examinations, and parents having abnormal vision were associated with children having abnormal vision. While adjusting for gender and age in the multivariable logistic regression analysis, watching TV for more than 3 hours every day was associated with abnormal vision. A Sudanese study suggested that watching TV for more than 2 hours per day in children under 5 years of age was a risk factor for abnormal vision.[17] A study of Irish children found that with longer smartphone screen time duration (ie, >3 h per day) and children from urban areas included, myopia was significantly more prevalent.[18] Research has found links between digital screen use and myopia or axial length increase,[19–21] one Chinese study showed screen time predicted reduced visual acuity.[22]

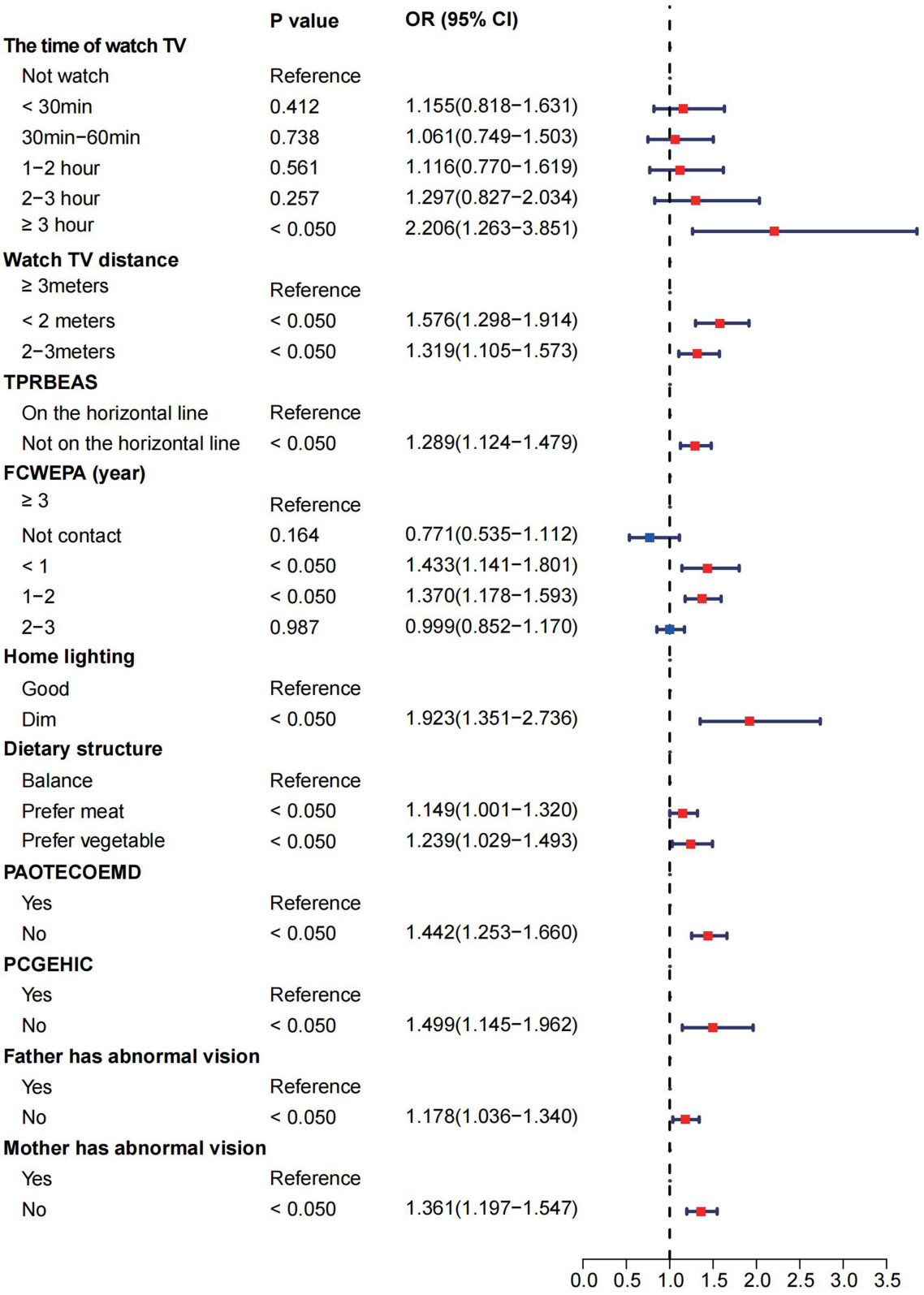

Figure 2 Multiple Logistic Regression Estimates of The Effect of Explanatory Variables on abnormal vision.
Abbreviations: TPRBEAS, the positional relationship between eyes and screen; FCWEPA, contact with electronic products age; PAOTECOEMD, parents' awareness of the effect chewing on eye muscle development; PCGEHIC, parents' cultivate good eye habits in children.

Children worldwide are increasingly using smart devices, which could contribute to an increase in myopia and its complications, such as irreversible vision loss.[23] Based on a meta-analysis of five studies, a recent systematic review published in 2020 found no association between digital screen time and prevalent or incident myopia.[24] Growing Up in Singapore Towards Healthy Outcomes (GUSTO) investigated early onset myopia (in participants aged 3 years) and found no increased risk with screen time.[25] Therefore, whether screen time is related to abnormal vision is worth further study.

Overuse of the eyes, improper reading posture, and prolonged use of the eyes in dark environments can lead to refractive errors. The popularity of electronic products and the reduction of outdoor activity time could have contributed to the high incidence and low age of onset of myopia.[26] However, due to the inadequate level of public health education, most parents lack sufficient knowledge regarding children's vision protection. Furthermore, the visual health education provided in schools is equally ineffective, adding to the challenge.

Our study found that watching TV at a distance of less than 3 meters was associated with a higher risk of abnormal vision. This finding was similar to previous studies showing a correlation between near work and myopia.[27] There was a study that found that the hyperopic defocus induced by accommodative lag during near work powerfully stimulates eye growth and causes elongation of axial length.[28] In this study, TPRBEAS was associated with abnormal vision; eyes and screen not being on the horizontal line was a risk factor for abnormal vision. Jiang et al[29] found that excessive lowering of the head is one of the risk factors for poor vision. However, Zadnik K believes that parents do not need to worry about children's screen time and distance; the greater relevance for eye protection is in terms of time spent outdoor.[30]

In the present study, it was determined that dim lighting within the household posed a risk factor for abnormal vision. Previous research has indicated that engaging in excessive near-work activities under insufficient lighting conditions during daylight hours has been identified as a prominent environmental factor contributing to the escalating prevalence of myopia in East and Southeast Asia.[16] Wen L et al's investigation revealed a significant correlation between increased daily light exposure and prolonged exposure to light levels exceeding 3000 lux per day with reduced axial eye elongation.[27] This protective effect is believed to be mediated by light-induced retinal dopamine, which inhibits aberrant eyeball growth.

Parents' lack of awareness of the effect of chewing on eye muscle development and failure to cultivate good eye habits in children were risk factors for myopia in children. Studies have found that the detection rate of abnormal vision in children who eat soft food is higher than that of children who eat hard food. The digestion and absorption of hard food require continuous chewing, which can stimulate the movement of facial muscles, enhance the adjustment ability of the lens, and promote the development of vision.[31]

Parental understanding and awareness of children's visual health play a critical role in mitigating the risk of permanent vision impairment. This is the same as a study conducted by Zheng-Yang Tao et al,[32] and they examined the impact of parental background and knowledge on the onset of myopia in children. In our study, PTCTURVE were not associated with abnormal vision, which was unlike other studies. There was a noteworthy correlation between parental awareness and visual screening. A study revealed that approximately half of parents had not taken their children for an eye check prior to preschool enrollment. A prominent factor for this non-attendance was parents' lack of awareness about the importance of visual screening for their children.[33] During the "critical period" from birth to the age of seven or eight, the visual system undergoes a rapid maturation stage.[34] During this period, the visual system is extremely sensitive to visual disturbances. These disturbances, especially amblyopia, may not have obvious symptoms, so it is necessary to conduct early screening to improve the predictability of treatment effects and achieve functional results.

Our study found that parental abnormal vision was also a risk factor for abnormal vision in children. When a father suffers from abnormal vision, the risk of having a child with the same condition increases 1.178-fold, whereas for mothers with abnormal vision, the risk of a child inheriting the condition rises 1.361-fold. Parental myopia is commonly recognized as a significant risk factor for the development of myopia in children.[35,36] A study in Australia suggests that features related to myopia are highly heritable.[37] Children of parents with abnormal vision are more likely to have abnormal vision.

The study encountered several limitations. First, it adopted a cross-sectional design, introducing inherent constraints. Second, the research population was confined to Chinese children, thereby limiting the extrapolation of findings to children in other nations. Consequently, the research results require validation through subsequent investigations.

Conclusions

Contact with electronic products plays a key role in the progression of abnormal vision among children aged 4 to 6. The family environment and genetic factors can also have a certain impact on vision. Therefore, regular screening of ocular conditions and prompt intervention could significantly contribute to the prevention of abnormal vision.

Ethics Approval and Consent to Participate

This study complies with the Declaration of Helsinki. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

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Disclosure

The authors declare no conflict of interest.

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